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Prevalence of canine parvovirus, vaccine-related, and other factors associated with the infection in dogs presented at the Veterinary Teaching Hospital in Kumasi, Ghana

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Abstract

Introduction: *canine parvovirus (CPV) infection is a contagious, sometimes fatal, viral disease primarily affecting young puppies worldwide. This is a cross-sectional study to determine the prevalence, vaccine-related, and other factors of canine parvovirus infection in dogs presented at the KNUST Veterinary Teaching Hospital in Kumasi, Ghana, between August 2023 and July 2024.* ***Methods:*** *faecal samples were collected from 211 suspected cases and tested using the V-check antigen test kit, a chromatographic immunoassay kit. Associated factors such as vaccination history, breed, age, and sex were assessed.* ***Results:*** *the results showed an overall prevalence rate of 61.14%, indicating a high disease burden. Age was significantly associated with CPV-2 infection ($p<0.05$), as puppies aged between 13-24 weeks and those aged less than 12 weeks showed high prevalence rates at 67.1% and 63.4%. Crossbreeds, german shepherds, and local dogs were the most susceptible breeds, with prevalence rates of 80.6%, 71.4% and 64.9%, respectively. Notably, CPV prevalence was also high in the vaccinated (60.8%) population, but this rate was comparatively lower than that of unvaccinated dogs at 63.3%.* ***Conclusion:*** *the study shows that CPV is a prevalent infection in dogs, and age, frequency of vaccination, and vaccination compliance appeared to influence CPV infection. High occurrence of CPV cases in the vaccinated population highlights the need to strengthen monitoring of vaccine management, vaccination protocol, and potential CPV-2 resistant strains. This study emphasizes the importance of strict vaccination compliance and public awareness to improve vaccination compliance to reduce CPV-2 infection rates in dogs.*

Introduction

Dogs worldwide commonly suffer from the highly virulent enteric disease known as Canine Parvoviral Enteritis (CPE), which is considered one of the most significant pathogenic viruses in the canine population [1]. Thus, it is important to understand the prevalence and vaccination challenges associated with the disease to reduce its spread and promote responsible pet care. Canine Parvoviral Enteritis is caused by canine parvovirus type 2 (CPV-2) belonging to the genus Protoparvovirus, within the family Parvoviridae [2]. Canine Parvoviral Enteritis is highly contagious among dogs, and it is of great concern to pet owners, veterinarians, and scientists due to its high morbidity (100%) and mortality (ranging from 10% - 91%) rates [2-4]. Puppies aged approximately six weeks to six months are the most susceptible to the disease [5]. However, dogs over six months old and up to two years old that are immunologically naïve may also be affected by the virus [5]. Young puppies, particularly those under three months of age, are more prone to severe clinical signs of CPV-2 infection [2].

Clinical signs of the disease often include lethargy, inappetence, vomiting, dehydration and severe diarrhoea that may be bloody [6]. The prevalence of CPV-2 within a population is primarily influenced by multiple factors, including the immunity of the host, breed, housing and hygiene, infectious co-pathogens like parasites, and the virulence of the CPV-2 strain causing the disease [7,8]. The primary approach to controlling CPE in the canine population is through vaccinations [9]. Vaccination using modified-live or attenuated CPV-2 vaccines is an effective way to safeguard dogs against all variants of CPV-2 (CPV-2a, CPV-2b, and CPV-2c), thus providing sustained immunity [1,10,11]. However, despite the

evidence supporting the efficacy of contemporary CPV-2 vaccines, the disease is still prevalent in vaccinated dogs in veterinary practice and remains of veterinary and economic significance [1,12]. Dogs may experience vaccination failures due to inadequate access to the vaccine, incorrect administration, persistence of maternally derived antibody titers, non-response to the vaccine, the emergence of various antigenic variants of the virus or incomplete vaccination courses [10,13,14] first documented the occurrence of canine parvoviral enteritis in Ghana, however, there is still a significant knowledge gap regarding the disease. This study was conducted to determine the prevalence of canine parvovirus infection and possible factors associated with the infection in dogs presented at the KNUST Veterinary Teaching Hospital in Kumasi, Ghana.

Methods

Study design: a prospective cross-sectional study in which faecal samples were collected from dogs suspected of canine parvovirus at the KNUST Veterinary Teaching hospital from August 2023 to July 2024.

Description of study area: the study was conducted at the KNUST Veterinary Teaching Hospital in Kumasi, Ashanti Region of Ghana. Kumasi is the second largest city in Ghana, with a land area of about 254 square kilometres. The KNUST Veterinary Teaching Hospital is located in Boadi, specifically at (6.685N, -1.544W).

Sample collection: faecal samples were obtained from dogs showing symptoms of canine parvovirus (CPV) infection, such as diarrhoea, anorexia, lethargy or vomiting. Faecal swabs were used to collect faeces directly from the rectum. Most of the samples collected were promptly tested, while those that were not immediately tested were stored at -20°c for future testing.

Sample size: per sample size calculation, approximately 365 dogs were to be sampled. The following formula was used [15]:

$$n = \frac{Z^2 p(1-p)}{d^2}$$

Where n= sample size, Z= risk of type 1 error (=1.96 at 95% confidence level) p= prevalence from previous study (61.1%) and d= absolute precision = 5% = 0.05. However, 211 dogs presented at the hospital during the study period met the sampling criteria.

Description of data collection forms: a standardized form was used to collect data for suspected cases from dog owners or caretakers, including patient details (age, sex, and breed), vaccination records (type of vaccine, brand, and administration dates) and laboratory results (V-Check CPV Ag test status and cutoff index (COI) levels).

Detection of canine parvovirus in samples: the collected faecal samples were tested using a V-check Ag Test Kit (Bionote Inc., Korea), a chromatographic immunoassay for qualitative detection of canine parvovirus antigen in canine faeces.

Test protocol: all materials were used and tested at room temperature (15-30°C). The testing was done according to the manufacturer´s instruction. The analyzer test result of a sample was given as positive (+) or negative (-) using a COI (cutoff index) value. The V200 analyzer (Bionote Inc., Korea) calculates COI by dividing a measured signal by an appropriate cutoff value. Test results of a COI ≥ 1.00 are considered positive for CPV antigen, while test results of a COI < 1.00 are considered negative for CPV antigen. The sensitivity and specificity of the test as indicated by the manufacturers were 100% and 100%, respectively (Bionote Inc, Korea). Furthermore, neither the quantitative value nor the concentration of CPV Ag can be determined by this qualitative test. However, the COI can help give an indication of the relative amount of antigen present, as the higher the COI, the more the antigen present (Bionote Inc, Korea).

Data analysis: the data was recorded in Microsoft Excel spreadsheet and subjected to statistical analysis using IBM SPSS statistics version 29. For univariable logistic regression and Chi-square analysis, a p-value of < 0.05 was considered statistically significant.

Results

Overall prevalence: from the study, 129, representing 61.14% of the 211 samples tested were positive for CPV, and 82, representing 38.86%, were negative for CPV. The COI for the negative cases ranged from 0.00 to 0.67, with a mean of 0.11, while the COI for the positive cases ranged from 1.23 to 47.23, with a mean of 26.79.

Sex prevalence: seventy-seven (58.78%) of male dogs tested positive for CPV, while 54 (41.22%) tested negative. Among female dogs, 52 (65%) tested positive, while 28 (35%) tested negative.

Age group prevalence: puppies between 13 to 24 weeks of age had the highest number of positive results, 57 out of 85 (67.06%), followed by puppies under 13 weeks of age with 54 (63.53%), lastly dogs over six months of age with 18 (43.09%).

Breed prevalence: the data revealed that local dogs most frequently tested positive. Out of the total sample of 57 local dogs, 37 (28.68%) tested positive, and 20 (24.39%) tested negative for CPV antigen. Crossbreeds were the second most common, with 31 dogs tested, of which 25 (19.38%) were CPV-positive and 6 (7.32%) were CPV-negative. This was followed by german shepherds, bullmastiffs, and boerboels, with 15 (11.63%), 12 (9.30%), and 11 (8.53%) cases of CPV-positive diagnoses, respectively. Several other breeds, including doberman (1), pug (1), siberian husky (1), and great dane (1), tested negative for CPV. However, the single (1) Shih Tzus and two (2) Belgian Malinois breeds that were presented during the study period tested positive. Other positive results were rottweilers, caucasian shepherds, poodles, maltese, and alsatian shepherds (Figure 1).

Canine parvovirus risk analysis: age group was significantly associated with canine parvovirus (CPV) infection (Table 1). Dogs over 24 weeks of age were less likely to be infected with CPV than dogs 12 weeks of age or younger, and dogs aged 13 to 24 weeks ($p< 0.05$). There was no significant association between CPV diagnosis and sex. Concerning breed, no significant association was observed between german shepherds (reference category) and all the other breeds tested. However, german shepherds had greater odds of being affected by CPV than all other breeds except crossbreeds. Crossbreed, german shepherd, and local dog recorded the highest prevalence with 80.6%, 71.4% and 64.9%, respectively.

CPV prevalence based on vaccination history: from the recorded vaccination data (Table 2), 57 (63.3%) out of the 90 dogs unvaccinated dogs tested positive for CPV, while 33 (36.7%) tested negative. Among the 102 vaccinated dogs, 62 (60.8%) tested positive for CPV, and 40 (39.2%) tested negative. The vaccination history of 19 dogs was unavailable, with 10 (52.6%) testing positive and 9 (47.4%) testing negative for CPV. Vaccination records of the vaccinated dogs showed that most of the dogs had received different vaccine brands and different doses (Table 3). Regarding vaccination frequency and CPV infection rates, no significant association was found (Table 4). However, the prevalence decreased from dogs vaccinated once to dogs vaccinated thrice, with the only exception being one dog vaccinated five times against canine parvovirus but succumbed to the disease. Due to the possibility that dogs could be incubating CPV before vaccine administration, the time interval between diagnosis and the last vaccination was assessed and the data was divided into two groups based on CPV incubation period (0-7 days before the onset of clinical signs). As indicated in Table 5, the difference in odds between the two groups was statistically insignificant ($p > 0.05$).

Dogs that were compliant to recommended vaccination schedule recorded a lower prevalence (57.9%) of canine parvovirus compared to non-

compliant dogs (66.7%). However, this difference was not statistically significant (p = 0.37) (Table 5). A client's dog was considered vaccine-compliant if vaccinations were administered according to the manufacturer´s recommendation, or informal national vaccination schedule. In Ghana, the routine vaccination schedule for CPV begins with the first dose at six to eight weeks of age, followed by booster doses at two-week intervals, usually completed by ten to twelve weeks of age. Thus, most dogs with a completed vaccination schedule would have received three initial (primary) doses as puppies, followed by annual booster vaccinations for life. For this study, dogs were considered vaccine-complaint if the vaccination dates for the first three initial (primary) vaccinations ranged from two to three weeks apart and then received yearly booster against the CPV, in accordance with their age at the time of case presentation and testing. Out of the 211 dogs tested, 66 had received at least two doses of the same brand of CPV vaccine, with 36 (54.5%) testing positive. Among the different vaccination categories, the most represented were dogs that received the same vaccine with incomplete dosage (45.5%), followed by those with the same vaccine and complete coverage (24.2%), and those that received different vaccine with complete coverage (21.2%). The least represented were dogs that received different vaccines with incomplete coverage (9.1%). There was no statistically significant association between the type of vaccine regimen (same or different vaccine and brand combination) and CPV infection (Table 5).

The local dog population had a significantly lower vaccination rate, with 56 out of 57 tested dogs (98.2%) being unvaccinated and none receiving more than a single dose of the CPV vaccine. In contrast, foreign breeds had notably higher vaccination rates with 101 out of 135 dogs (74.8%) vaccinated. Dogs older than 24 weeks were vaccinated three times against CPV at a rate of 28.6%, which is higher than the 17.3% vaccination rate for dogs aged 13 to 24 weeks and the 7.3% rate for those under 13 weeks. However, they received a single vaccination less frequently, at 5.7%, compared to 14.7% for dogs aged 13 to 24 weeks and 28% for those under 13 weeks. Thus, vaccination rates varied significantly across the different age groups (p = 0.003). However, there was no significant association between sex and vaccination frequency (p = 0.89) (Table 6).

Discussion

Canine parvoviral enteritis continues to pose a significant challenge to dogs in several countries across the globe due to its high morbidity and mortality rate despite the availability of vaccines [10,16]. The overall prevalence of CPV-2 in dogs in this study was 61.14%, similar to findings by [14] in Kumasi, Ghana, where the prevalence among was 61.11%, indicating a high disease burden. This persistent high prevalence of CPV-2 in the Kumasi Metropolis, Ghana, highlights the endemicity of the virus and the high risks of CPV-2 infection to immune-naïve dogs in the area. Similar studies conducted in North Central Nigeria [17] and Yaoundé, Cameroon [18] reported lower prevalence rates of 45% and 40.2%, respectively, while studies in areas such as Giza Governorate, Egypt [19] and Nigeria [11] reported higher prevalence of 72.67% and 93%, respectively. These varying rates, although lower or higher when compared to the current study, still reflect a high CPV-2 presence within the canine population in many areas.

Age was a significant risk factor for CPV infection (p < 0.05) in this study, with infection rates of 67.1% and 63.5% recorded in young dogs aged 13-24 weeks and those aged 12 weeks or less, respectively. These findings agree with previous studies by Mekky *et al.* [19] and [20], both of which reported a significant association between age and CPV-2 infection. Studies from Egypt by Ogbu *et al.* and Sayed-Ahmed *et al*. [17,21] also recorded the highest prevalence of CPV infection among dogs between 0 to 24 weeks old at 65.9% and 0-6 months old at 49.19%. The susceptibility of dogs less than six months of age to CPV-2

infection can be attributed to their maternal antibody interference and a decreased likelihood of achieving full vaccination coverage before exposure to the virus, which is particularly important in preventing CPV infection.

The breed of dogs was not significantly associated with CPV infection ($p > 0.05$), though crossbreeds, german shepherds, local dogs, caucasian shepherds, and bullmastiffs recorded higher susceptibility rates of 60% or more. These results are consistent with findings by Folitse *et al* [14], who reported the highest prevalence rates in rottweilers, boerboels, crossbreeds, and bullmastiffs in Ghana. The difference in breed dynamics might be due to changes in breeds commonly kept as household pets over the years in the area, breeding practices, or an increased sense of awareness, responsibility, and accessibility to veterinary care over the years. Regarding the proportion of breed positivity for CPV, local breeds accounted for the most cases with 28.68%, followed by crossbreeds, german shepherds, and bullmastiffs at 19.38%, 11.63%, and 9.30% of the total positive cases, respectively.

This trend is similar to Mebanga *et al.* [18] in Cameroon, where cane corso, crossbreeds, german shepherd, and local dogs accounted for the most positive CPV cases. The notion that local dogs are resistant to canine parvoviral enteritis did not hold in this study, as this breed was the most represented. This biased perception may suggest a preference for foreign breeds among clients who can easily afford veterinary care for their pets [22], as local breeds were even less vaccinated (98.5%) in this study compared to foreign breeds (25.2%). Financial constraints have been cited as a significant challenge in vaccination against CPV-2 in other studies [23-25]. This trend of increased CPV cases in local dogs is similar to Ogbu *et al.* [17] in Nigeria and [18] in Cameroon, who also recorded a high prevalence of 42.86% and 40% in their study, which may be due to more local dog owners taking their pets to the clinic when needed than was done previously [26]. The rottweiler breed also recorded a moderately high prevalence rate of 50%, though lower compared to other studies [14,17,19].

The sex of dogs was not significantly associated with CPV infection($p>0.05$), which was similar to other studies [17,20,26]. The prevalence of CPV was slightly higher in female dogs (65%) than in male dogs (58.8%), which agrees with the studies by Ogbu *et al*. and Miranda *et al*. [17,20], where higher susceptibility rates were reported among females than males. However, the findings of this study are contrary to those reports by Folitse *et al.* Mebanga *et al.* and Ukwueze *et al.* [14,18,27], where male dogs demonstrated a greater susceptibility compared to females.

This study also examined the vaccination history of dogs presented and found that even dogs vaccinated (complete/incomplete) had a relatively high prevalence of CPV, at 60.8%. This rate was, however, slightly lower than that in unvaccinated dogs at 63.3%. Thus, CPV infection was not significantly associated with vaccination status, which agrees with similar findings by Folitse *et al.* [14] and Ogbu *et al.* [17]. These findings contrasts that of Perley *et al.* [28] in the United Kingdom, where vaccination was significantly associated with CPV infection, as unvaccinated dogs were more than twice as likely to be infected with CPV compared to vaccinated dogs. These variations in the study areas may be due to differences in socioeconomic factors, veterinary personnel, improper dosing interval or incomplete vaccination courses, vaccine protocol or administration, vaccine transportation or storage, an unreliable vaccine source or different variants of circulating CPV-2 in the areas [10,14,19,23,29]. This may indicate that vaccination, though important, may not necessarily be effective in all cases if certain conditions are not met.

Interestingly, this study found that dogs vaccinated three times or more often had a low prevalence of CPV compared to those vaccinated once and twice. The CPV positivity rates decreased from 72.2% in dogs vaccinated once to 55.6% and 51.7% in those vaccinated twice and thrice,

respectively. This agrees with the assertion by the vaccination guidelines group (VGG) of the world small animal veterinary association (WSAVA) that multiple sequential doses of vaccinations at appropriate intervals can induce immune priming to cover dogs against CPV-2 infection better [25]. Regardless of the decreasing trend, the high prevalence in dogs vaccinated three times (51.7%) might be due to the majority of them finishing their primary course of vaccinations earlier than 16 weeks of age, which has been associated with vaccination failure due to the interference of antibodies [23,25]. Uncharacteristically, one dog (Boerboel) had received four primary vaccinations as a puppy with a subsequent yearly booster, which was up to date yet succumbed to a CPV-2 challenge. This might have been due to the dog being a non-responder to the vaccine or vaccination failure which was similarly reported by Decaro *et al.* [5].

The maintenance and active use of companion animal disease surveillance systems to adjust vaccination protocols to community-specific needs in veterinary medicine have yet to be successful [23]. The directions for vaccine usage provided by the manufacturer's instructions on veterinary vaccine labels are based on experimental data at the time of the vaccine's launch and may not accurately reflect the changing needs of community-based infections [23]. In Ghana, the recommended vaccination schedule commonly used (as previously outlined) was used to ascertain vaccination compliance for this study. The results indicated that compliance with vaccination was an influencing factor in the susceptibility rates of CPV infection. Among compliant dogs, 57.9% tested positive for CPV, while the proportion was higher (66.7%) for CPV-positive cases in the non-compliant category. Therefore, inconsistent vaccination schedules increase a dog's risk of CPV infection as it might encounter a CPV-2 challenge before building an adequate immune response [17] also reported vaccination compliance as a risk factor for CPV-2 infection.

The use of the same or different vaccine brands was not significantly associated with CPV-2 infection ($p > 0.05$). However, higher susceptibility rates were recorded in dogs that received a complete course of different vaccine brands (64.3%) and those that received an incomplete course of the same vaccine brand (60%) compared to those that completed the full course with the same brand (43.8%) and those that received incomplete course of different brands (33.3%). This inconsistency may be due to the usage of several vaccine brands in this dataset or a limited sample size, as those that received incomplete course from different brands accounted for 9.1% of the sample population. Additionally, not all vaccine brands might be necessarily protective against all variants of canine parvovirus in some areas; hence, intermixing them in the vaccination schedule with other vaccines, even if the other offers better protection against CPV-2 variants, might delay adequate immune response, exposing the dog to CPV-2 infection.

Dogs were also assessed on the possibility of incubating CPV-2 before vaccine administration. Of the dogs tested during the study, 15.7% were within 0-7 days, while 84.3% were tested more than seven days after vaccination, with 56.3% and 61.6% susceptibility rates, respectively. In the former, vaccination failure could be due to their exposure to the CPV-2 virus before receiving their vaccine dose. On the other hand, the higher prevalence in dogs tested more than seven days after vaccination may be due to the inability of dogs to mount sufficient immune response between the time of vaccination and exposure to the field virus. Breeders or dog owners can, therefore, be advised to adhere to adequate biosecurity measures such as disinfection of households or restricted access to certain areas prior to the completion of the vaccination regimen.

The vaccination coverage in the local dog population was very low compared to that of foreign dogs in this study, which raises concerns regarding the vaccination status of local dogs and

the significant role they might play in the spread of CPV-2 in the environment. Achieving herd immunity against CPV-2 in the canine population will be difficult if immunization rates against the virus are low [10]. The financial commitment it takes to cover dogs even for a minimum of three times for the primary vaccination against CPV-2 during an early age poses challenges to some dog owners, which might even explain the only vaccinated local dog being vaccinated once against CPV-2.

Information or recall bias could have affected the accuracy of vaccination records, as the dog owners or caretakers primarily provided these. Also, the molecular characterization or strain typing of the CPV-2 virus, which may give an idea regarding different strains contributing to the infections in vaccinated and unvaccinated dogs, was outside the scope of this study. Finally, this study did not factor in various confounding variables, such as underlying health conditions, deworming history, nutrition, and environmental risks, which could have influenced dogs' susceptibility to CPV infection.

Conclusion

This study highlights the high persistence of canine parvovirus infection among the dogs in Kumasi, Ghana. Age was significantly associated with the disease, with younger dogs being more susceptible, while no significant association was found with breed, sex, or vaccination history. However, the frequency of vaccination and vaccination compliance appeared to influence CPV infection, since incompletely or inconsistently vaccinated dogs showed higher susceptibility. Although vaccination is intended to offer protection, the high occurrence of CPV cases in the vaccinated population, though lower than in the unvaccinated, underscores the need for ongoing evaluation of vaccine management, adherence to recommended vaccination protocol, and surveillance of potentially vaccine-resistant CPV-2 strains.

Recommendations: this study offers valuable insights into the epidemiology of CPV and vaccination patterns in dogs in Kumasi, Ghana. Educational initiatives are essential to improve dog owners' understanding and appreciation of vaccination schedules. Emphasis should be on complete and timely vaccinations since incompleteness or failure to vaccinate on time exposes dogs to an increased risk for CPV-2 infection. Further research is necessary to investigate the epidemiology of circulating CPV-2 strains and to conduct vaccine response studies. These efforts will help determine whether current vaccines offer adequate protection or if updated formulations are required to address emerging viral variants.

What is known about this topic

- *Canine parvoviral enteritis (CPV-2) is a highly contagious and deadly disease affecting dogs, especially puppies, worldwide;*
- *Age, breed, immune status, and vaccination history are significant factors influencing susceptibility to CPV infection;*
- *Vaccination failures against CPV-2 occur due to improper administration, schedule non-compliance, and resistant viral strains.*

What this study adds

- *The study identifies a high CPV-2 prevalence of 61.14% in dogs in Kumasi, Ghana, highlighting the virus's endemicity in the region;*
- *This current study shows that even vaccinated dogs exhibit high infection rates (60.8%), suggesting potential vaccine management or resistance issues;*
- *The study provides insights into demographic and breed-specific susceptibility, with crossbreeds, german shepherds, and local dogs being most affected and low vaccination rates among local dogs.*

Competing interests

The authors declare no competing interests.

Authors' contributions

Jemima Dzigbordi Agbota and Raphael Deladem Folitse were responsible for conceptualizing the study, designing the methodology, data collection, analyzing the data, and drafting the original manuscript. Emmanuel Opoku Darko, William Tasiame, Dorcas Oyuele Kodie and Benjamin Obukowho Emikpe contributed to data analysis, as well as reviewing and editing the manuscript. All the authors read and approved the final version of this manuscript.

Tables and figures

Table 1: univariable logistic regression analysis of possible predisposing factors associated with canine parvovirus infection

Table 2: canine parvovirus diagnosis based on vaccination status

Table 3: results based on type of vaccine and frequency of vaccination

Table 4: chi-square analysis of results based on vaccination frequency

Table 5: univariable logistic regression analysis of vaccination-related factors associated with CPV infection

Table 6: chi-square analysis of results relating to frequency of vaccination and predisposing factors

Figure 1: bar chart displaying CPV diagnosis by breed

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Table 1: univariable logistic regression analysis of possible predisposing factors associated with canine parvovirus infection								
Predisposing Factor	**Positive**	**Negative**	**Total**	**Total %**	**Prevalence %**	**p-value**	**Odds ratio**	**95% CI**
		Sex (male/female)						
Male	77	54	131	62.09	58.8%	0.37	0.77	0.43-1.37
Female	52	28	80	37.91	65%			
Total	129	82	211					
		Age group in weeks						
More than 24 weeks	18	23	41	19.43	43.9%	0.04	Ref	
Less than or equal to 12 weeks	54	31	85	40.28	63.5%	0.04	0.45	0.21-0.96
13 to 24 weeks	57	28	85	40.28	67.1%	0.01	0.38	0.18-0.83
Total	129	82	211					
		Breeds						
German shepherd	15	6	21	10.0	71.4%	0.20	Ref	
Local dog	37	20	57	27.0	64.9%	0.59	1.35	0.45-4.03
Boerboel	11	14	25	11.8	44%	0.066	3.18	0.92-10.92
Bullmastiff	12	8	20	9.5	60%	0.44	1.67	0.45-6.13
Rottweiler	8	8	16	7.6	50%	0.19	2.50	0.64-9.77
Caucasian shepherd	8	5	13	6.2	61.5%	0.55	1.56	0.36-6.76
Crossbreed	25	6	31	14.7	80.6%	0.44	0.60	0.16-2.20
Poodle	6	6	12	5.7	50%	0.22	2.50	0.57-10.93
Maltese	2	2	4	1.9	50%	0.41	2.50	0.28-22.04
Minor breeds	5	7	12	5.7	41.7	0.099	3.50	0.79-15.50
Total	129	82	211	100%	61.14%			
CI = confidence interval								

Table 2: canine parvovirus diagnosis based on vaccination status			
Vaccination status	**CPV-**	**CPV+**	**Total**
No	33 (36.7%)	57 (63.3%)	90 (42.7%)
Yes	40 (39.2%)	62 (60.8%)	102 (48.3%)
Not available	9 (47.4%)	10 (52.6%)	19 (9.0%)
Total	82 (38.9%)	129 (61.1%)	211(100%)
CPV= canine parvo virus			

Table 3: results based on type of vaccine and frequency of vaccination				
Type of vaccine	**Vaccination Frequency**	**CPV+**	**CPV-**	**Total**
Biocan DHPPi+L only	1	9	3	12
	2	3	2	5
	3	1	3	4
Canvac P-IN puppy parvo[a] and Biocan DHPPi+L[c]	5	1	0	1
Canigen DHPPi/L only	2	4	1	5
Nobivac 1-Pv puppy parvo only	1	5	2	7
	2	4	2	6
PROVAC DHPPL only	1	9	4	13
	2	4	3	7
	3	2	2	4
Vanguard Plus 5/L DHPPL only	1	3	1	4
	2	4	3	7
	3	2	5	7
Eurican DHPPi-L only	2	0	1	1
Biocan DHPPi+L[b] and PROVAC DHPPL[a]	3	5	0	5
Biocan DHPPi+L[a] and PROVAC DHPPL[a]	2	1	2	3
Biocan DHPPi+L[a] and nobivac 1-Pv puppy parvo[a]	2	1	0	1
Biocan DHPPi/L[a] and canigen DHPPi/L[a]	2	0	1	1
Biocan DHPPi/L[b] and Vanguard Plus 5/L DHPPL[a]	3	1	0	1
Canigen DHPPi/L[a] and PROVAC DHPPL[a]	2	0	1	1
Nobivac 1-Pv puppy parvo[a] and vanguard plus 5/L DHPPL[b]	3	1	2	3
PROVAC DHPPL[b] and vanguard plus 5/L DHPPL[a]	3	2	1	3
Biocan DHPPi+L[a] and vanguard plus 5/L DHPPL[b]	3	0	1	1
Total		62	40	102
a = vaccinated once with that vaccine, b = vaccinated twice with that vaccine, c = vaccinated four times with that vaccine; DHPPL= Distemper, Hepatitis, Parvovirus, Parainfluenza, and Leptospirosis; CPV: canine parvo virus				

Table 4: chi-square analysis of results based on vaccination frequency					
Vaccination frequency	CPV-	CPV+	Total	Chi-square	p - value
Once	10 (27.8%)	26 (72.2%)	36 (35.3%)	3.09	0.21
2 times	16 (44.4%)	20 (55.6%)	36 (35.3%)		
3 times	14 (48.3%)	15 (51.7%)	29 (28.4%)		
5 times	0	1 (100%)	1 (1.0%)		
Total	40 (39.2%)	62 (60.8%)	102 (100%)		
CPV= canine parvo virus					

Table 5: univariable logistic regression analysis of vaccination-related factors associated with Canine Parvo Virus infection								
	CPV diagnosis		**Prevalence%**	**Total**	**Total%**	**p-value**	**Odds ratio**	**95% CI**
	Positive	**Negative**						
Vaccination status		**(Vaccinated/unvaccinated)**						
Yes	62	40	60.8%	102	53.1%	0.72	0.90	0.50-1.61
No	57	33	63.3%	90	46.9%			
Total	119	73	62%	192	100%			
Time from last vaccination to date of CPV diagnosis (interval) in days (lesser than or equal to 7/greater than 7)								
Less than or equal to 7	9	7	56.3%	16	15.7%	0.69	0.80	0.27-2.36
Greater than 7	53	33	61.6%	86	84.3%			
Total	59	40	60.8%	102	100%			
Vaccination compliance			**Compliant/non-compliant**					
Compliant	33	24	57.9%	57	55.9%	0.37	0.69	0.31-1.55
Non-compliant	30	15	66.7%	45	44.1%			
Total	63	39	61.8%	102	100%			
Same or different vaccine types used								
Same complete	7	9	43.8%	16	24.2%	0.45	Ref	
Same Incomplete	18	12	60.0%	30	45.5%	0.30	0.52	0.15-1.77
Different complete	9	5	64.3%	14	21.2%	0.26	0.43	0.10-1.89
Different incomplete	2	4	33.3%	6	9.1%	0.66	1.56	0.22-11.09
Total	36	30	54.5%	66	100%			
CI = confidence interval, CPV = canine parvo virus								

Table 6: chi-square analysis of results relating to frequency of vaccination and predisposing factors								
	None	**Once**	**Twice**	**Thrice**	**Five times**	**Total**	**Chi-square**	**p- value**
Breed/number of times vaccinated								
Local breed	56 (98.2%)	1 (1.8%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	57 (29.7%)	-	-
Foreign breed	34 (25.2%)	35 (25.9%)	36 (26.7%)	29 (21.5%)	1 (0.7%)	135 (70.3%)		
Sex/number of times vaccinated								
Male	56 (47.1%)	22 (18.5%)	22 (18.5%)	18 (15.1%)	1 (0.8%)	119 (62%)	0.63	0.89
Female	34 (46.6%)	14 (19.2%)	14 (19.2%)	11 (15.1%)	0 (0.0%)	73 (38%)		
Age group in weeks/number of times vaccinated								
Less than or equal to 12 weeks	36 (43.9%)	23 (28.0%)	17 (20.7%)	6 (7.3%)	0 (0.0%)	82 (42.7%)	20.19	0.003
13 to 24 weeks	37 (49.3%)	11 (14.7%)	14 (18.7%)	13 (17.3%)	0 (0.0%)	75 (39.1%)		
More than 24 weeks	17 (48.6%)	2 (5.7%)	5 (14.3%)	10 (28.6%)	1 (2.9%)	35 (18.2%)		

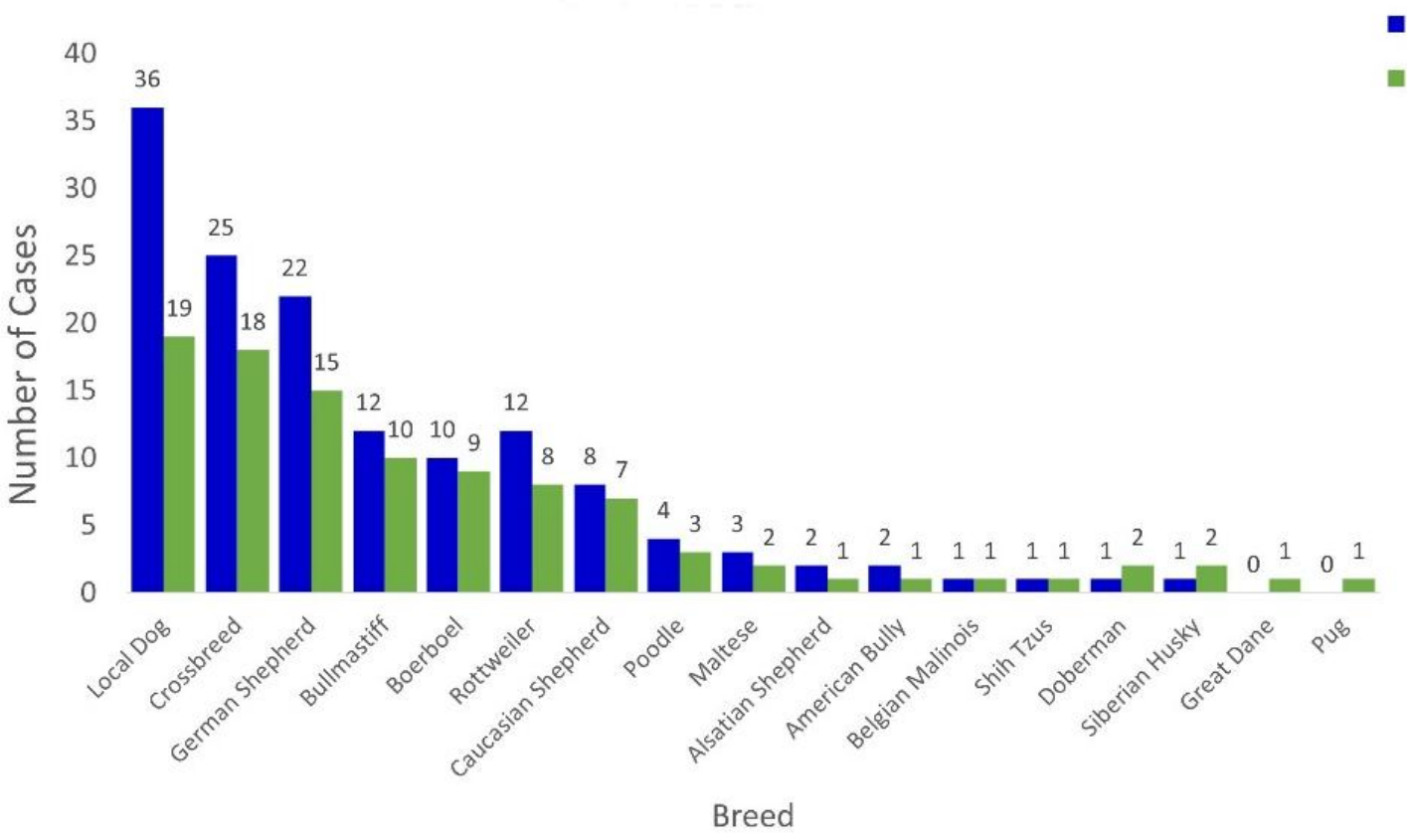

Figure 1: bar chart displaying CPV diagnosis by breed